

# **INDOOR AIR QUALITY ASSESSMENT**

**Brockton Public Library East Branch  
54 Kingman Street  
Brockton, Massachusetts**



Prepared by:  
Massachusetts Department of Public Health  
Center for Environmental Health  
Bureau of Environmental Health Assessment  
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## **Background/Introduction**

At the request of Harry Williams, Director of the Brockton Public Library (BPL), the Massachusetts Department of Public Health (MDPH), Center for Environmental Health's (CEH), Bureau of Environmental Health Assessment (BEHA) was asked to provide assistance and consultation regarding indoor air quality in each of the BPL's facilities (Main Library, East Branch and West Branch). Mr. Williams was referred to MDPH by Brockton Public Health Officials. On November 10, 2004, a visit to conduct an assessment was made to the East Branch of the Brockton Public Library (EBBPL), located at 54 Kingman Street, Brockton, Massachusetts by Cory Holmes, an Environmental Analyst in BEHA's Emergency Response/Indoor Air Quality (ER/IAQ) Program. Keith Choquette, Assistant Director, BPL and Karen King, East Branch Director, accompanied Mr. Holmes, for portions of the assessment. The EBBPL is the subject of this report. The West Branch and Main Library will each be the subject of separate reports.

The EBBPL is a one-story brick structure built in 1969. A handicapped access ramp was later installed. Library officials reported that no other major renovations have been conducted and the majority of building materials (e.g., carpeting, heating and ventilation components, ceiling tile systems) are original. The main floor of the library contains the circulation desk, main office, open stack areas, restrooms, and computer stations. The finished basement contains an auditorium, kitchen/break room, boiler room and storage area. Windows on the main floor are openable, however occupants reported that many are difficult to operate. For security reasons, the majority of windows in the basement have been temporarily sealed with plexiglass.

## **Methods**

BEHA staff performed a visual inspection of building materials for water damage and/or microbial growth. Moisture content of porous building materials (e.g., carpeting, insulation, ceiling tiles) was measured with Delmhorst, BD-2000 Model, Moisture Detector with a Delmhorst Standard Probe. Air tests for carbon dioxide, carbon monoxide, temperature and relative humidity were taken with the TSI, Q-TRAK™ IAQ Monitor, Model 8551.

## **Results**

The EBBPL has 4-6 employees working daily, and up to 200 members of the public visit on a daily basis. Tests were taken during normal operations and results appear in Table 1.

## **Discussion**

### **Ventilation**

It can be seen from the Table 1 that carbon dioxide levels were below 800 parts per million parts of air (ppm) in all but one area surveyed, indicating adequate ventilation in the majority of areas at the time of the assessment. However, it is important to note that most areas were sparsely populated, which would contribute to reduced carbon dioxide levels. Carbon dioxide levels would be expected to rise during full occupation especially given the current condition and lack of operation of the mechanical ventilation system.

Fresh air is mechanically provided to the building through unit ventilator (univent) systems (Pictures 1 and 2). A univent draws air from outdoors through a fresh air intake

located on the exterior wall of the building (Picture 3). Fresh air intakes for basement level univents are located in concrete-lined subterranean pits (Picture 4). Return air for the univent is drawn through an air intake located at the base of the unit ([Figure 1](#)). Fresh and return air are mixed, filtered, cooled/heated and provided to occupied areas through an air diffuser located in the top of the unit. Univents have manual fan controls of low, medium and high to adjust fan speed (Picture 5). Univents were found deactivated and inoperable in a number of areas. In order for univents to provide fresh air as designed, they must be activated and allowed to operate while rooms are occupied. As previously discussed, univents are reportedly original, approximately 30-35 years old. Univents of this age can be difficult to maintain because replacement parts are often unavailable.

The mechanical exhaust ventilation system consists of ceiling- and/or wall-mounted vents (Pictures 2, 6 and 7) ducted to motors, which are located either above the ceiling tile system or in the attic. At the time of the assessment, a number of exhaust vents were not operating (Table 1), which indicates that motors had either been deactivated or were not operable. In addition, the passive vent in the door to the main office behind the circulation desk had been removed (Picture 8). With the door closed, no make up air is available to the main office. Without dilution by the introduction of fresh air via the univents and removal by the exhaust ventilation system, normally occurring environmental pollutants can build up and lead to indoor air/comfort complaints.

Facilitating the mechanical ventilation system in the building are openable windows. Occupants reported that windows in several areas are broken, in disrepair or have been temporarily sealed for security reasons (Pictures 9 and 10). In a number of cases, openable windows have been eliminated with the permanent installation of window-

mounted air conditioners. The air conditioners are equipped with a “fan only” or “exhaust open” setting (Picture 11). Operating air conditioning units in either of these modes can provide air circulation, since outside air is delivered without cooling (i.e., air provided by unit equals that of outside temperature).

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a univent and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. It is recommended that HVAC systems be re-balanced every five years (SMACNA, 1994). The date of the last balancing of these systems was not available at the time of the assessment.

The Massachusetts Building Code requires that a room must a minimum ventilation rate of 20 cubic feet per minute (cfm) per occupant of fresh outside air or openable windows (BOCA, 1993; SBBRS, 1997). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health

Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information on carbon dioxide see [Appendix A](#).

Temperature measurements ranged from 70° F to 75° F, which were within the BEHA comfort guidelines. The BEHA recommends that indoor air temperatures be maintained in a range of 70° F to 78° F in order to provide for the comfort of building occupants. Temperature control complaints in a number of areas were expressed to BEHA staff during the assessment. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. It is also difficult to maintain temperature without operating the ventilation system as designed (e.g., univents and exhaust fans deactivated/not operable) and with windows sealed or in disrepair.

The relative humidity measured in the building ranged from 25 to 35 percent, which was below the BEHA recommended comfort range. The BEHA recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating.

The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

### **Microbial/Moisture Concerns**

In order for building materials to support mold growth, a source of moisture is necessary. Identification and elimination of water moistening building materials is necessary to control mold growth. Materials with increased moisture content over normal concentrations may indicate the possible presence of mold growth. Identification of the location of materials with increased moisture levels can also provide clues concerning the source of water supporting mold growth. In an effort to ascertain moisture content of porous materials, samples were taken in areas impacted by water damage (i.e., ceiling tiles, insulation and carpeting). A number of non-effected areas were measured for comparison.

Water content of building materials was measured with a Delmhorst, BD-2000 Model, Moisture Detector with a Delmhorst Standard Probe. The Delmhorst probe is equipped with three lights that are visual aids indicating moisture level. Readings that activate the green light indicate a sufficiently dry level (0 - 0.5%), those that activate the yellow light indicate borderline conditions (0.5 – 1.0%) and those that activate the red light indicate elevated moisture content (> 1%). The probe is inserted into the surface of porous materials for measurement.

A few areas had water damaged ceiling tiles, which can indicate leaks from the roof or plumbing system (Picture 12). Water damaged ceiling tiles can provide a source of mold and should be replaced after a water leak is discovered and repaired. Concerns of

mold growth in this area were expressed by occupants. BEHA staff removed a number of tiles to examine conditions above the ceiling plenum. The plenum above the ceiling tiles was insulated with fiberglass, some of which appeared water damaged. Moisture measurements of ceiling tiles and insulation in this area were low during the assessment.

Water damaged carpeting was observed near the basement entrance/handicapped access ramp (Picture 13). This area is equipped with exterior drainage, however occupants reported that water penetration occurs periodically during heavy driving rains. Moisture measurements of carpeting in this area were low during the assessment. The US Environmental Protection Agency (US EPA) and the American Conference of Governmental Industrial Hygienists (ACGIH) recommends that porous materials be dried with fans and heating within 24 to 48 hours of becoming wet (US EPA, 2001; ACGIH, 1989). If porous materials are not dried within this time frame, mold growth may occur. Water damaged porous materials cannot be adequately cleaned to remove mold growth. The application of a mildewcide to moldy porous materials is not recommended.

As discussed several subterranean pits were located along the perimeter of the building (Picture 4). These pits allow airflow into below grade air intakes for the mechanical ventilation system. Leaves, papers and other debris were observed on the bottom of the pits (Picture 14), which can provide a source of mold growth. Mold odors and growth can subsequently be entrained into the ventilation system and distributed to occupied areas.

The basement contains a storeroom with a cement floor. BEHA staff observed a large number of cardboard boxes and other porous items stored on the floor (Picture 15).



These items should be elevated (e.g., placed on pallets, tables) to prevent water damage and potential mold growth.

Plants were noted in several areas (Picture 16). Plants can be a source of pollen and mold, both of which can be respiratory irritants for some individuals. Plants should be properly maintained and equipped with drip pans. Plants should also be located away from univents to prevent the aerosolization of dirt, pollen or mold.

Several areas contained dehumidifiers. Dehumidifiers and/or humidifiers contain a reservoir for standing water. This equipment should be cleaned/maintained as per the manufactures instructions to prevent mold/bacterial growth and associated odors.

### **Other Concerns**

Several other conditions that can affect indoor air quality were noted during the assessment. Libraries in general have a large number of flat and irregular surfaces (e.g., book shelves, books) that provide a source for dusts to accumulate. These surfaces are also difficult for custodial staff to clean. Dust can be irritating to eyes, nose and respiratory tract. Items should be removed and/or be cleaned periodically to avoid excessive dust build up.

In addition, several univents were opened, and BEHA staff inspected the interior. Accumulated dust and debris was observed (Pictures 17 and 18). The operation of univent fan motors can aerosolize dust particles. In addition, these materials can accumulate on flat surfaces (e.g., desktops, shelving and carpets) in occupied areas and subsequently be re-aerosolized causing further irritation.

Carpeting in several areas was extremely worn and damaged (Picture 19). Library staff reported that these carpets often emit musty odors. The carpet was reportedly installed during the original construction of the building, which would make it over thirty years old. Disintegrating textiles can be a source of particulates, which can be irritating to the eyes, nose and throat. Carpet fibers/particulate matter can also be entrained and suspended in air by the mechanical ventilation system.

Finally, as discussed, several areas contained window-mounted air conditioners. These units are equipped with filters, which should be cleaned or changed as per the manufacturer's instructions to avoid the build up and re-aerosolization of dirt, dust and particulate matter.

## **Conclusions/Recommendations**

The indoor air quality problems at the East Branch of the Brockton Public Library raise a number of issues. The general building conditions, maintenance, work hygiene practices and the age/condition of ventilation equipment, if considered individually, present conditions that can degrade indoor air quality. When combined, these conditions can serve to further negatively affect indoor air quality. Some of these conditions can be remedied by actions of building occupants. Other remediation efforts will require alteration to the building structure and equipment. For these reasons a two-phase approach is required. This approach consists of **short-term** measures to improve air quality and **long-term** measures requiring planning and resources to adequately address overall indoor air quality concerns.

The following **short-term** measures should be considered for immediate implementation:

1. Operate all ventilation systems throughout the building continuously during periods of occupancy. To increase airflow during full occupancy, set univent controls to “high”.
2. Contact an HVAC engineer to evaluate the ventilation control system and survey univents for function. Consider having univent fresh air control dampers calibrated building-wide.
3. Restore the general exhaust ventilation system. Inspect exhaust motors and belts for proper function, repair and replace as necessary.
4. Supplement airflow by opening windows and operating air conditioners in the “Fan Only” setting to introduce outside air.
5. Work with staff to determine which windows are unopenable/difficult to operate and make repairs. Consider removing plexiglass from auditorium windows.
6. Balance mechanical ventilation systems every five years, as recommended by ventilation industrial standards (SMACNA, 1994). Consult a ventilation engineer concerning re-balancing of the ventilation systems.
7. Work with city officials to develop a preventative maintenance program for all HVAC equipment system wide.
8. Change filters for window-mounted air conditioners and air-handling equipment as per manufacturer’s instructions or more frequently if needed. Vacuum interior of units prior to activation to prevent the aerosolization of dirt, dust and particulates. Ensure filters fit flush in their racks with no spaces in between allowing bypass of unfiltered air into the unit.

9. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Avoid the use of feather dusters. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
10. Ensure roof/plumbing leaks are repaired, and replace any remaining water-damaged ceiling tiles and fiberglass insulation. Examine the area above and around these areas for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial as necessary. Conduct work above ceiling tiles during *unoccupied* periods or periods of low occupancy. Once work is completed wet wipe and/or vacuum area with a HEPA filtered vacuum cleaner to clean up all residual dirt, dust and particulates.
11. Consider removing water-damaged section of carpeting around auditorium exterior door and replacing with tile or other non-porous floor material.
12. Remove leaves and debris from subterranean pits seasonally.
13. Ensure plants have drip pans. Examine drip pans periodically for mold growth and disinfect with an appropriate antimicrobial where necessary.
14. Do not store porous materials directly on cement floor in basement storage room. Inspect and discard any water damaged cardboard boxes. Disinfect any areas of microbial growth with a one in ten bleach in water solution; wipe clean surfaces with soap and water after disinfection.

15. Clean and maintain dehumidifiers as per manufacturer's instructions.
16. Consult "Mold Remediation in Schools and Commercial Buildings" published by the US EPA (2001) for further information on mold. Copies of this document can be downloaded from the US EPA website at:  
[http://www.epa.gov/iaq/molds/mold\\_remediation.html](http://www.epa.gov/iaq/molds/mold_remediation.html).
17. Refer to resource manuals and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. These materials are located on the MDPH's website at  
<http://www.state.ma.us/dph/beh/iaq/iaqhome.htm>.

The following **long-term** measures should be considered:

1. Consider contacting HVAC engineering firm fully evaluate the ventilation systems  
Based on the age, physical deterioration and availability of parts for ventilation components, BEHA strongly recommends this measure.
2. Consider replacing damaged/worn carpeting throughout the library to prevent the aerosolization of carpet fibers.
3. Repair/replace loose/broken windowpanes and missing or damaged window caulking building-wide to prevent water penetration through window frames.
4. Repair and/or replace thermostats and controls as necessary to maintain control of thermal comfort. Consider contacting an HVAC engineer concerning the repair and calibration of thermostats and ventilation controls building-wide.

## References

ACGIH. 1989. Guidelines for the Assessment of Bioaerosols in the Indoor Environment. American Conference of Governmental Industrial Hygienists, Cincinnati, OH.

BOCA. 1993. The BOCA National Mechanical Code-1993. 8<sup>th</sup> ed. Building Officials & Code Administrators International, Inc., Country Club Hills, IL. M-1601 et al.

OSHA. 1997. Limits for Air Contaminants. Occupational Safety and Health Administration. Code of Federal Regulations. 29 C.F.R 1910.1000 Table Z-1-A.

SBBRS. 1997. Mechanical Ventilation. State Board of Building Regulations and Standards. Code of Massachusetts Regulations. 780 CMR 1209.0

SMACNA. 1994. HVAC Systems Commissioning Manual. 1<sup>st</sup> ed. Sheet Metal and Air Conditioning Contractors' National Association, Inc., Chantilly, VA.

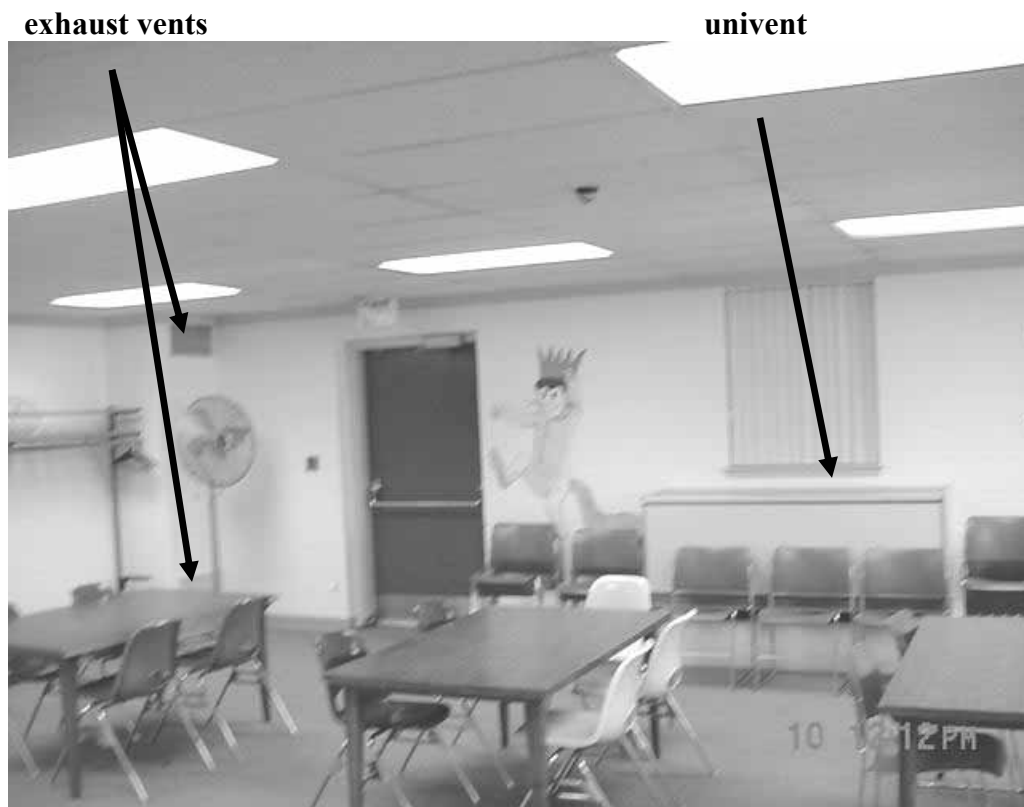
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**Picture 1**



**Small Unit Ventilator on Main Level of Library**

**Picture 2**



**Unit Ventilator and Wall-Mounted Exhaust Vents in Basement Auditorium**



**Picture 3**



**Univent Fresh Air Intake**

**Picture 4**



**Subterranean Concrete-Lined Pit for Univent Fresh Air Intake**

**Picture 5**



**Univent Control Panel, Fan Speed Control Buttons along top,  
Also Note Vent On/Off Control at Bottom**

**Picture 6**



**Ceiling-Mounted Exhaust Vent in Main Office**

**Picture 7**



**Passive Door Vents and Ceiling-Mounted Exhaust Vent in Basement Kitchen**

**Picture 8**



**Solid Door Panel in Main Office Door**

**Picture 9**



**Broken/Repaired Glass Window Pane on Main Floor**

**Picture 10**



**Auditorium Window Sealed with Plexiglass**



Picture 11



**Air Conditioner Control Panel Note Fan and Fresh Air Controls**

**Picture 12**



**Water Damaged Ceiling Tiles in Main Portion of the Library, Note Water Damaged Fiberglass Insulation Above Tiles in This Area**

**Picture 13**



**Water Damaged Carpeting and Door Jamn in Basement Auditorium**

**Picture 14**



**Leaves and Debris at the Bottom of Univent Air Intake Pit**

**Picture 15**



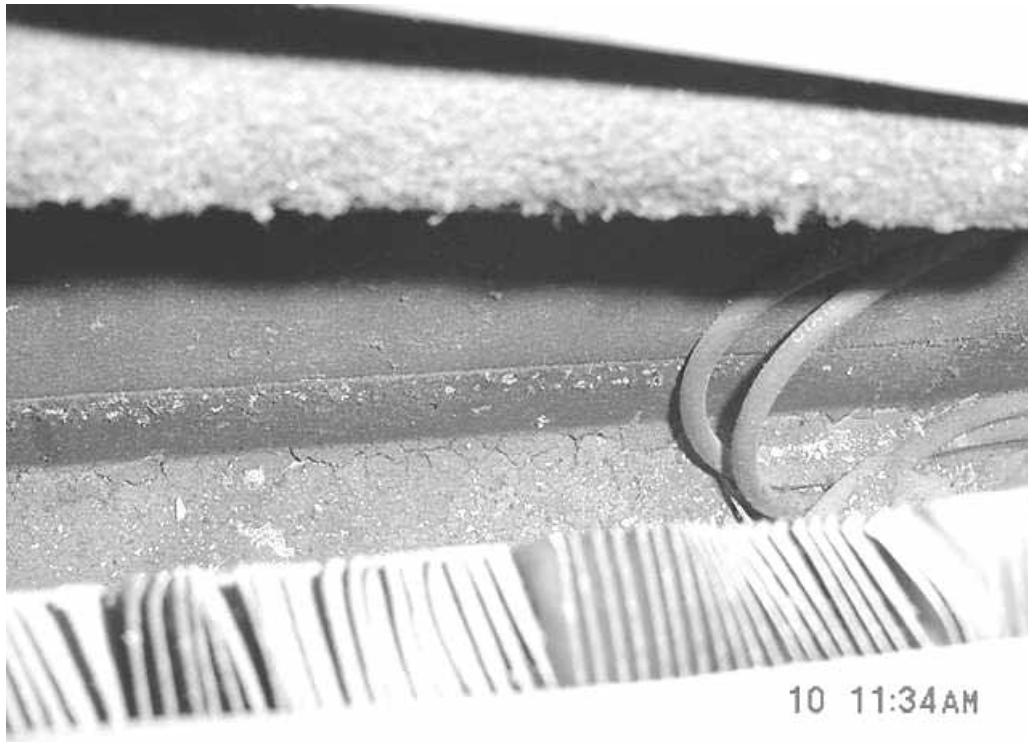
**Boxes and Other Items Stored on Cement Floor of Basement Storeroom**

**Picture 16**



**Plants on Bookshelf**

**Picture 17**



**Acuumulated Dirt, Dust and Debris inside Univent Air Handling Chamber**

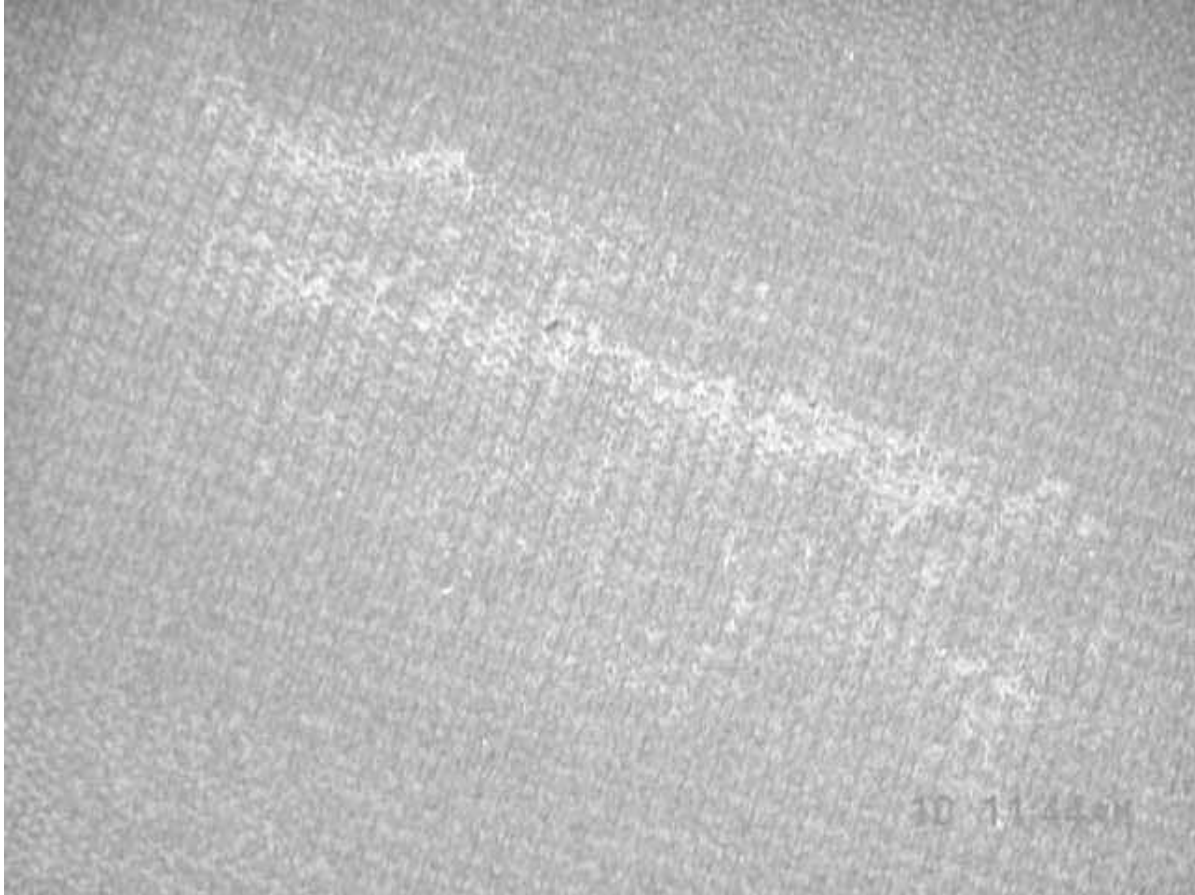
**Picture 18**



**Accumulated Dirt, Dust and Debris inside Univent Control Panel**



**Picture 19**



**Worn/Damaged Carpeting on Main Floor**

TABLE 1

**Indoor Air Test Results – Brockton Public Library East Branch, 54 Kingman St., Brockton, MA – November 10, 2004**

Location	Carbon Dioxide (*ppm)	Temp (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
Background	365	73	39					Clear, sunny and cold
Stacks 914-998	522	74	22	0	Y	Y	Y	
Fiction Center Stack	628	74	22	0	Y	Y	N	UV not operating
Mysteries Stacks	522	75	21	0	Y	Y	N	
Circulation Desk	624	76	21	5	N	Y	N	
Main Office	899	75	22	4	N	Y passive	Y	Ceiling exhaust vent – no draw, passive door vent sealed
Children's Area	607	76	21	0	Y	Y	N	
Children's Stacks P-W	584	76	20	0	Y	Y	N	
Basement Auditorium	467	74	18	0	Y	Y	Y	UV-off and exhaust not operating, most of the windows sealed with plexiglass, water damaged carpet/door jamb
Breakroom/ Kitchen	460	74	19	0	N	Y passive	Y	Passive door vents, exhaust not operating

\* ppm = parts per million parts of air

**Comfort Guidelines**

Carbon Dioxide - < 600 ppm = preferred  
600 - 800 ppm = acceptable  
> 800 ppm = indicative of ventilation problems

Temperature - 70 - 78 °F

Relative Humidity - 40 - 60%

**TABLE 1**

**Indoor Air Test Results – Brockton Public Library East Branch, 54 Kingman St., Brockton, MA – November 10, 2004**

Location	Carbon Dioxide (*ppm)	Temp (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
Basement Storage	498	74	22	0	Y	N	Y	Cardboard boxes and other items stored on cement floor, exhaust vent not operating

\* ppm = parts per million parts of air

**Comfort Guidelines**

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%